Figure 1 : Full mesh network

Node G

Node H

Node F

201

200

Node E
Back Ups

Node E

Node D

Node B

Node A

Node C

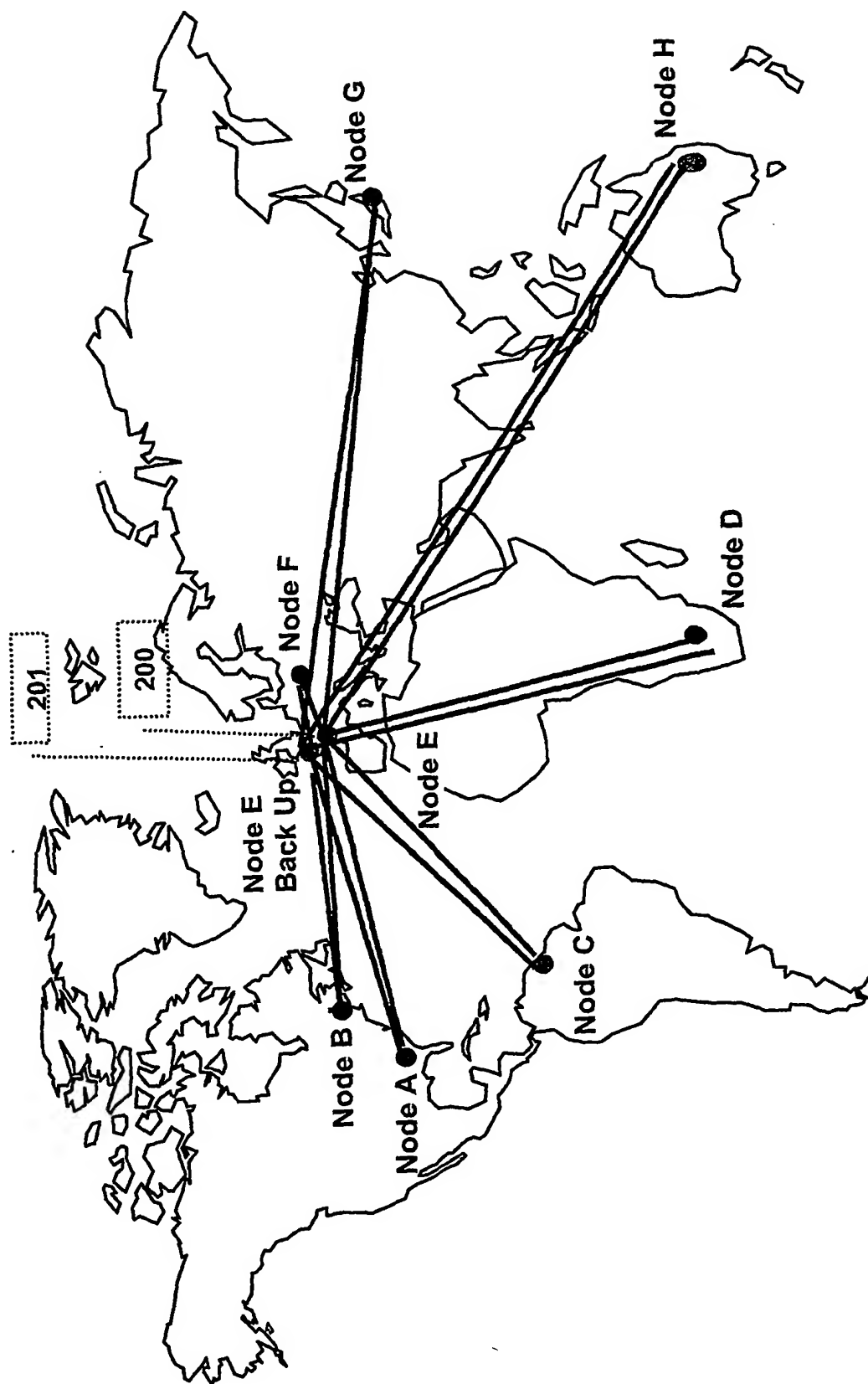Figure 2: Star network
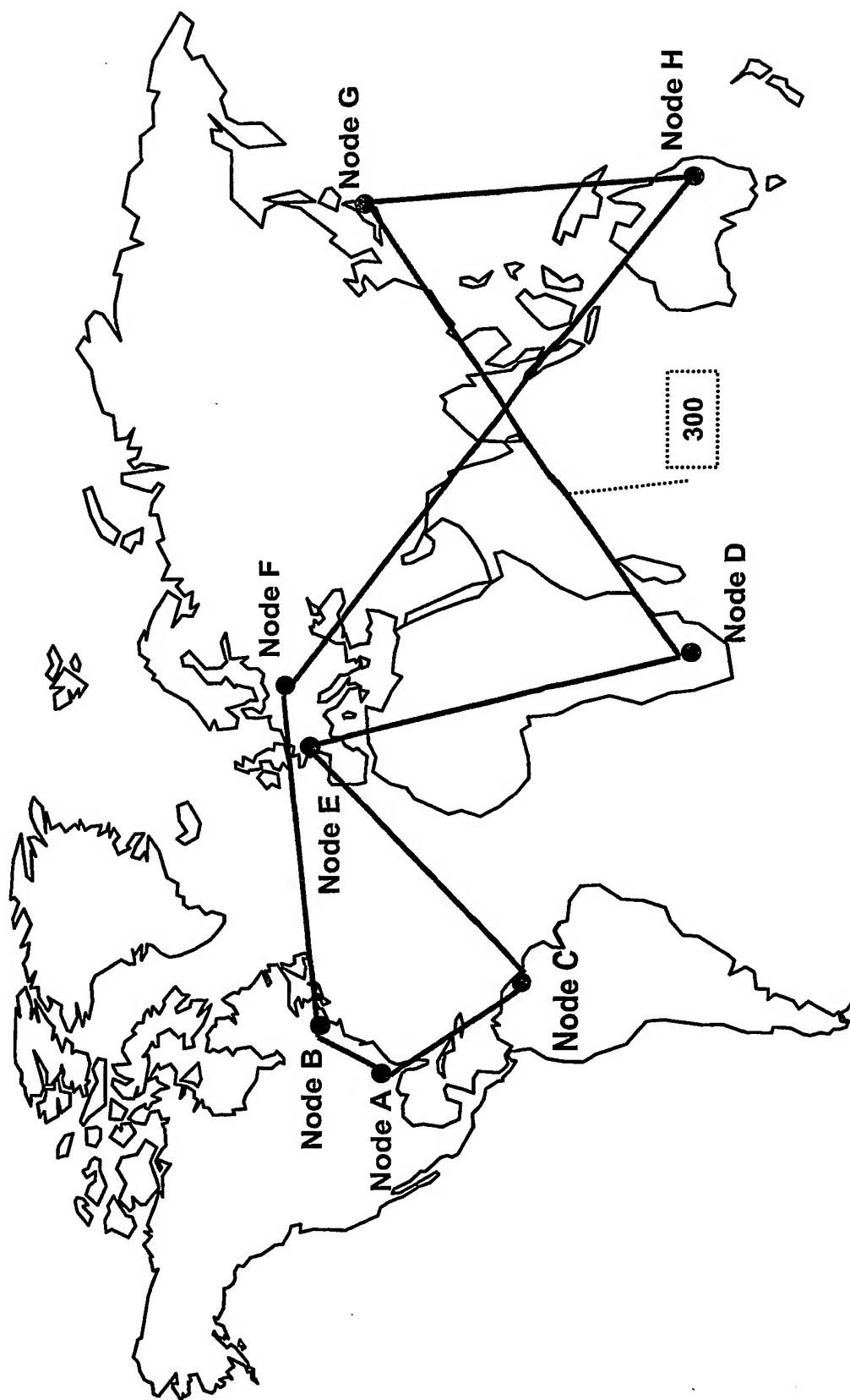
Figure 3: Virtual Ring Network
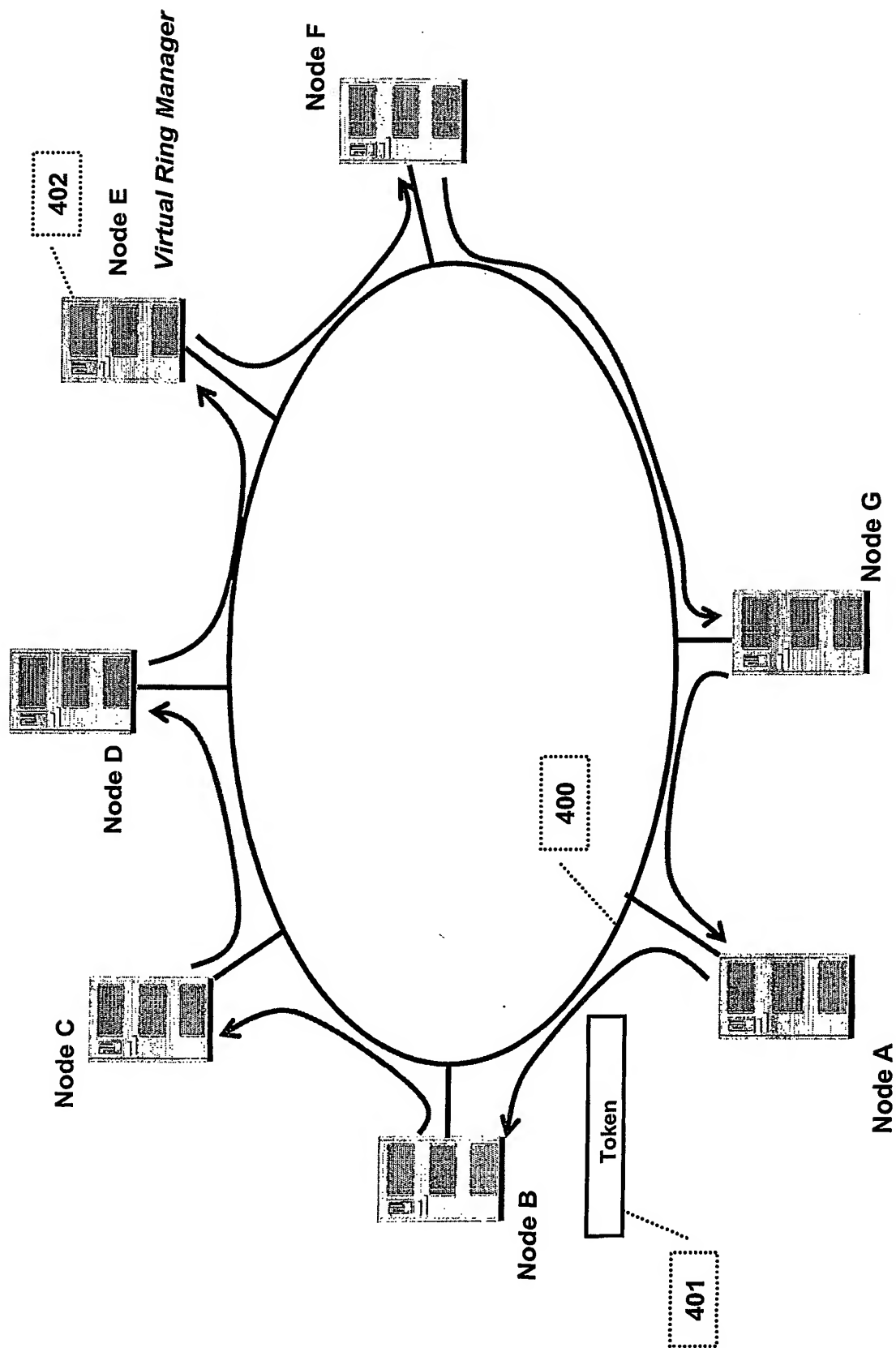
Figure 4: Token on Virtual Ring

IP Header	TCP Header	Virtual Ring Token		
Header	Source/Dest Port	Message Code 0x0001	Virtual Ring Identifier (2 bytes)	Sequence Number (4 bytes)

500   501   502   503   504   505
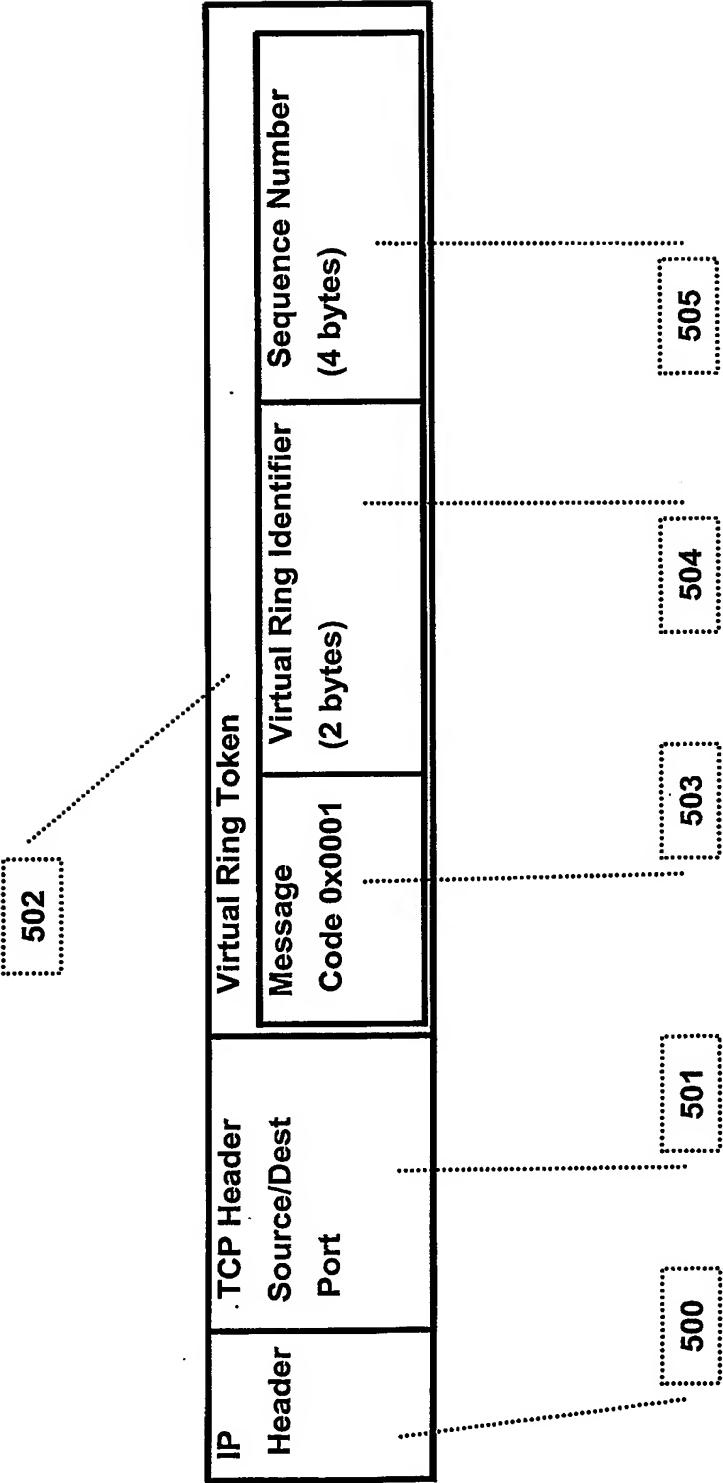
Figure 5: Token description
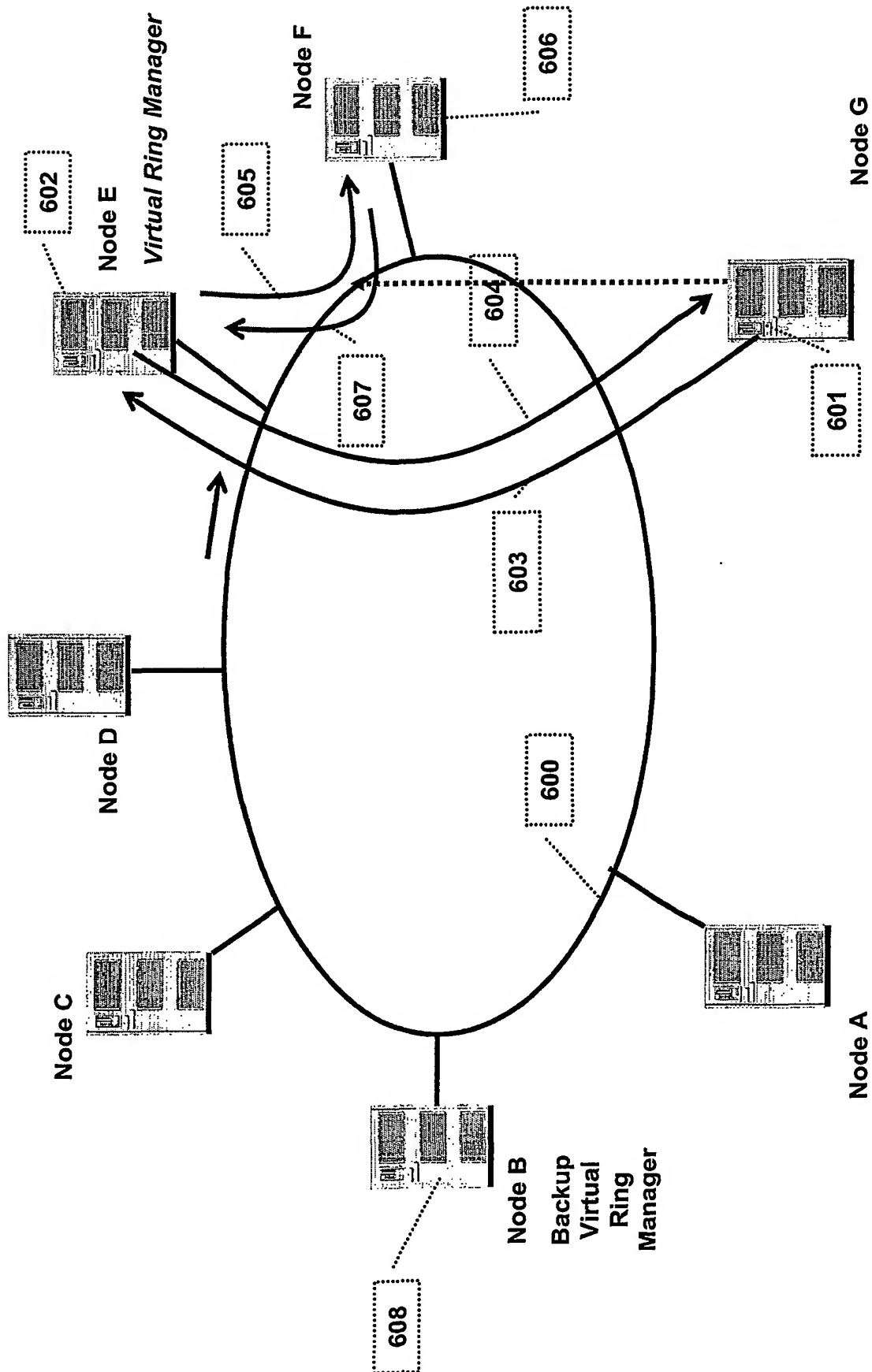
Figure 6: Node insertion on the Virtual Ring
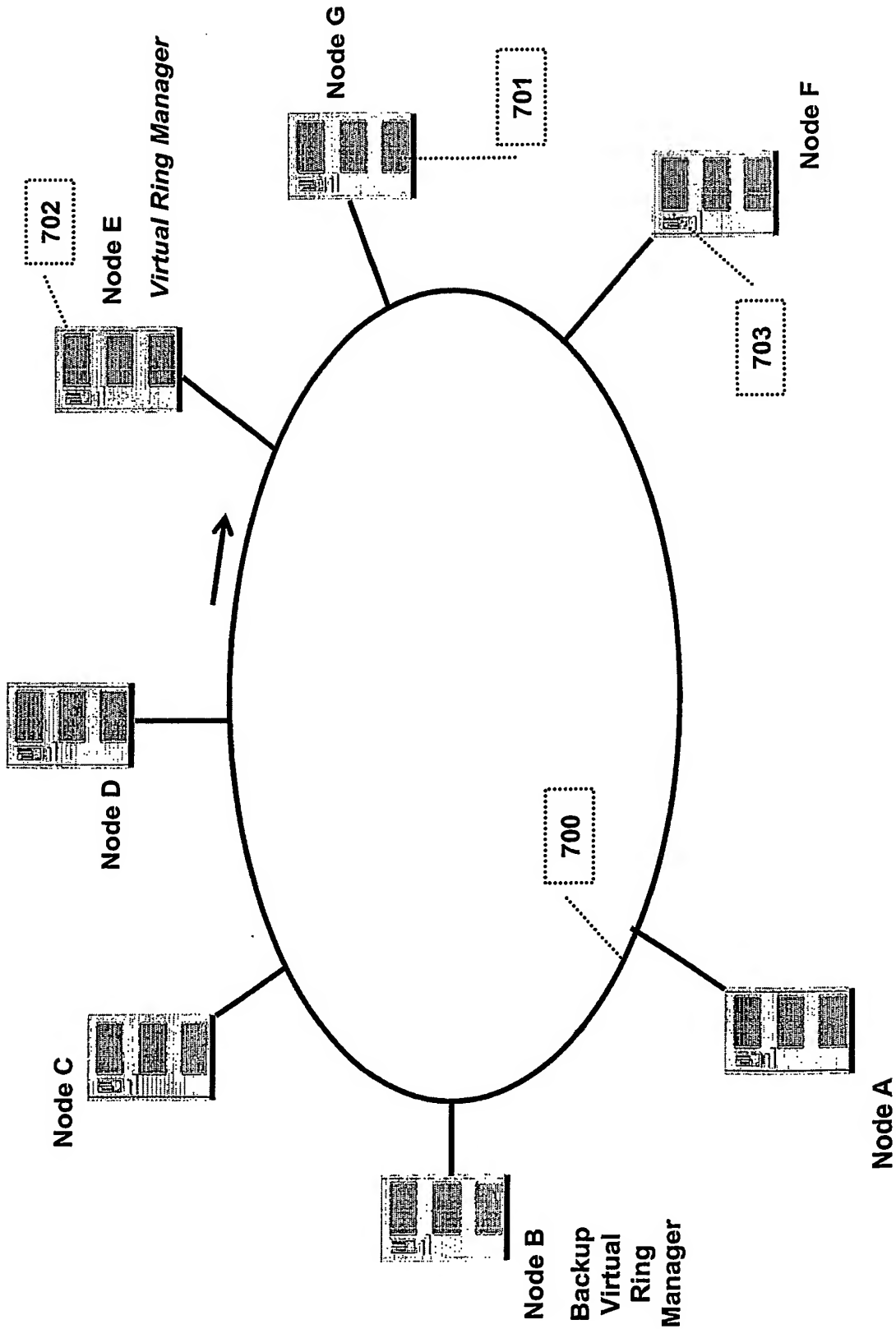
Figure 7: Node insertion on the Virtual Ring - Result
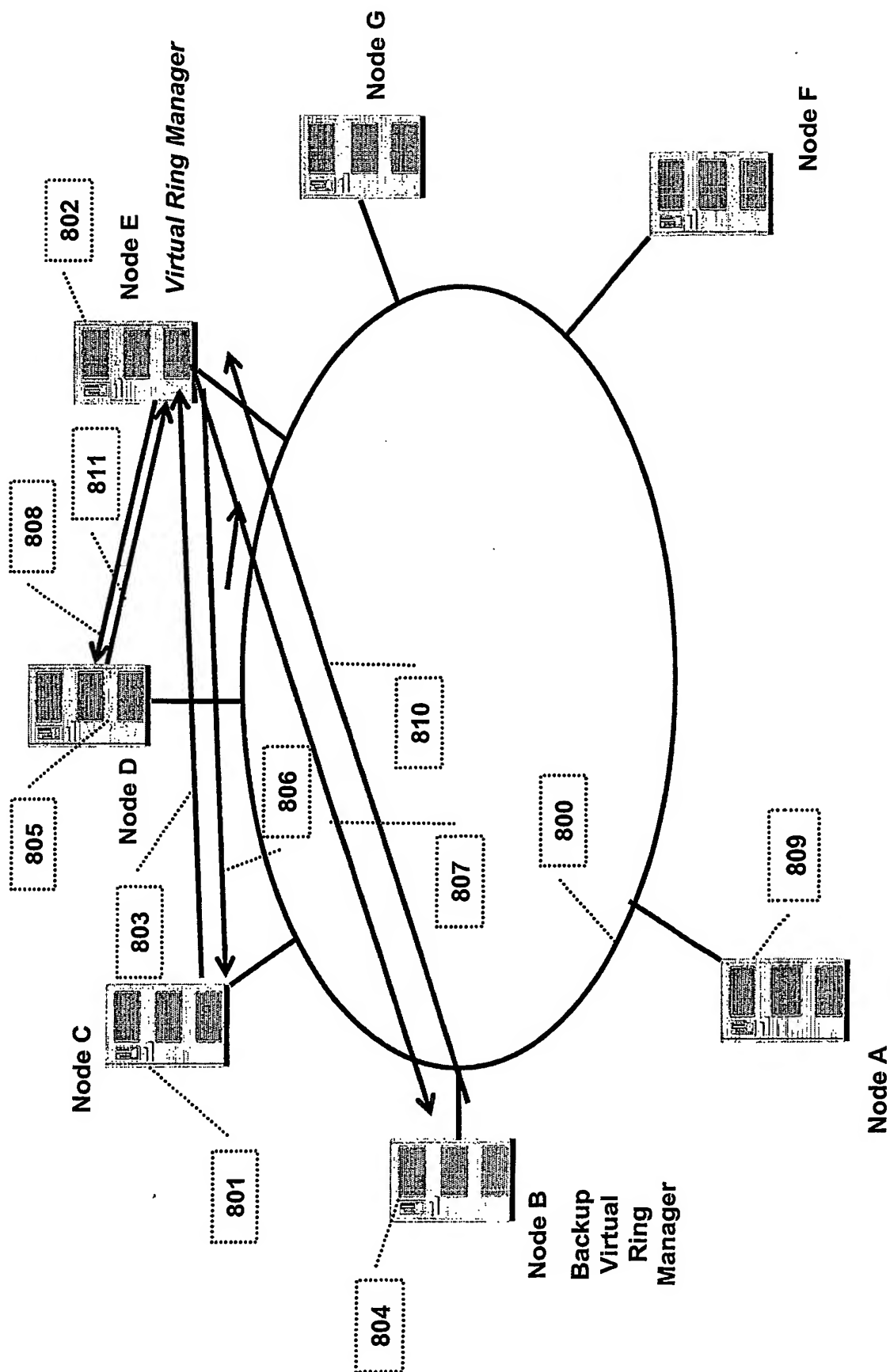
Figure 8: Node solicited removal from the Virtual Ring

Node G

Node F

902

Node E

Virtual Ring Manager

905

906

909

904

Node D

910

907

908

900

Node C

901

Node A

903

Node B
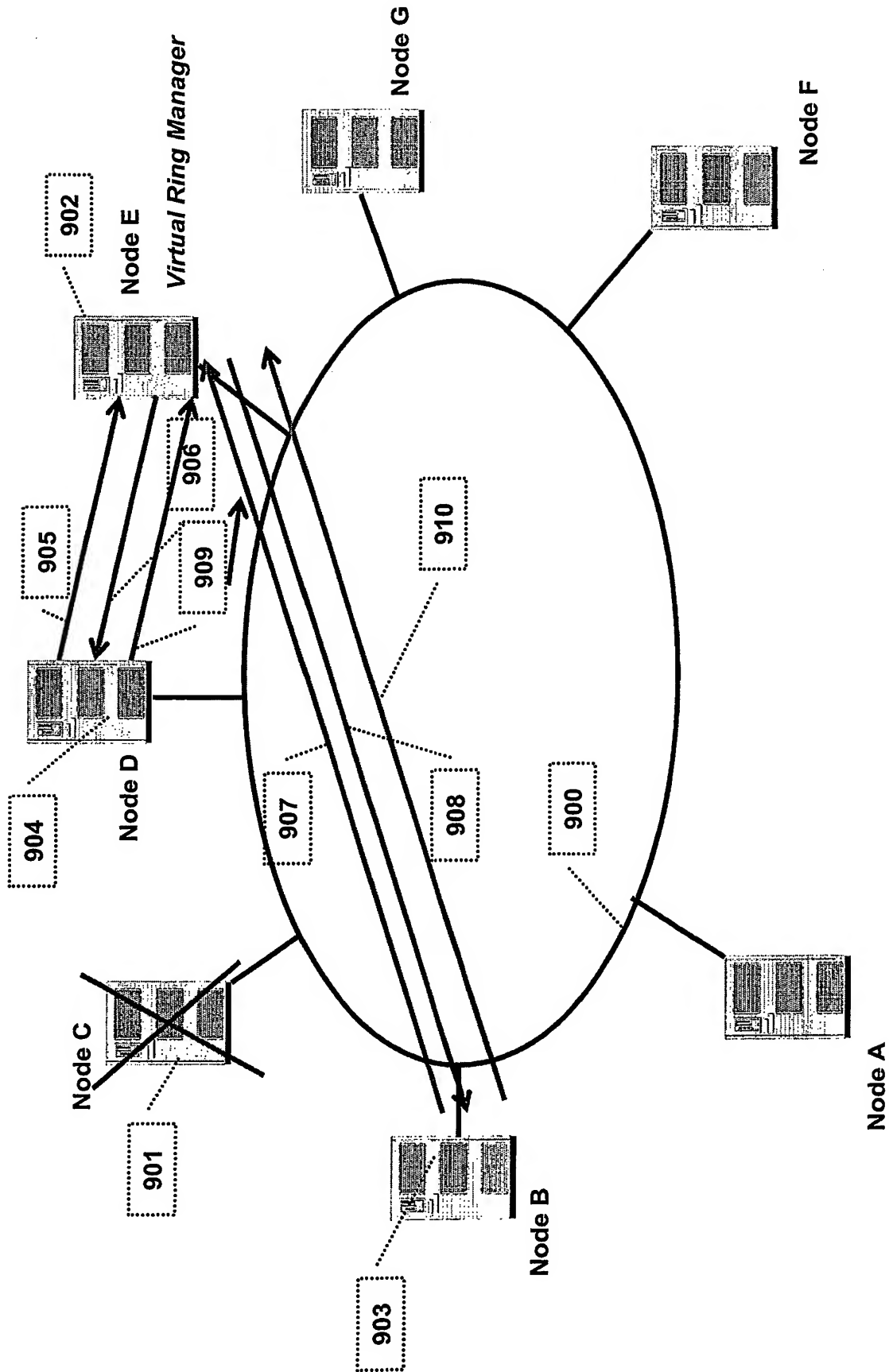
Figure 9: Loss of a Node
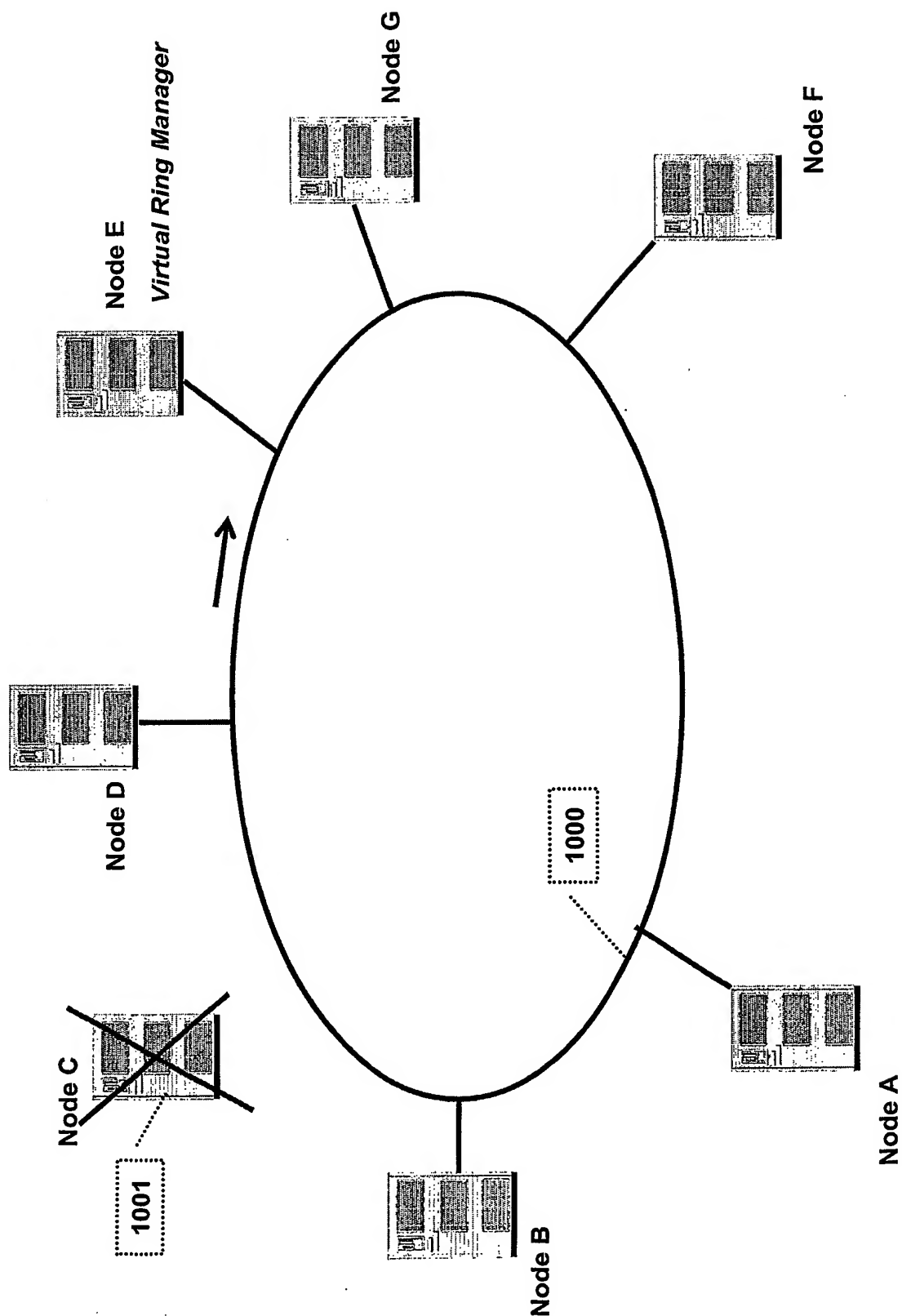
Figure 10: Loss of a Node - Result

Start 1100

Start Wait Token Timer=30s 1101

Token Received ? 1102

Wait Token Timer Expired 1103

Ring Recovery procedure 1106

Sequence Nb.=previous +1 ? 1104

Forward Token to the Downstream Neighbor 1105

No

Yes

No

Yes

No

Yes
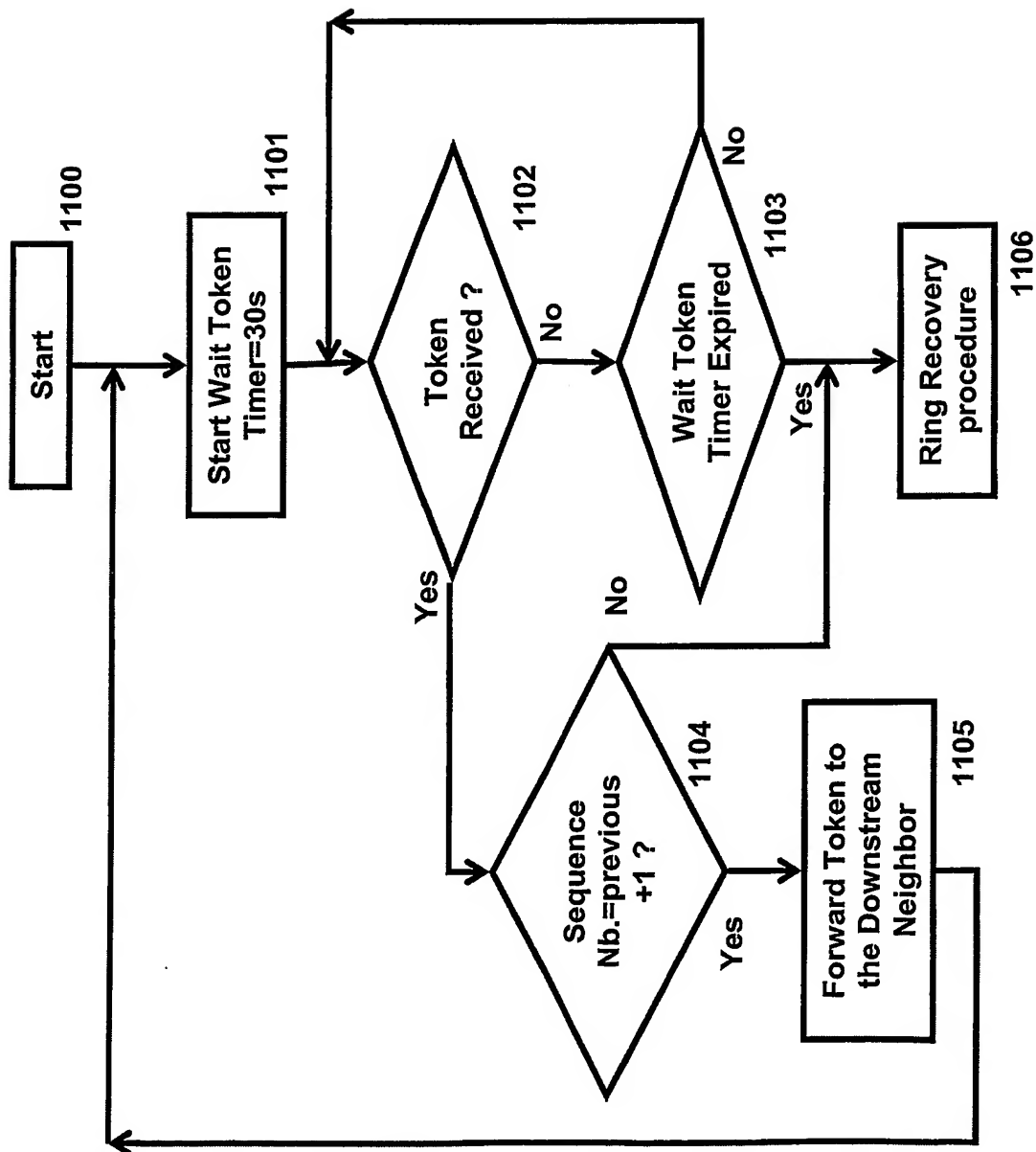
Figure 11: Token Processing by a node
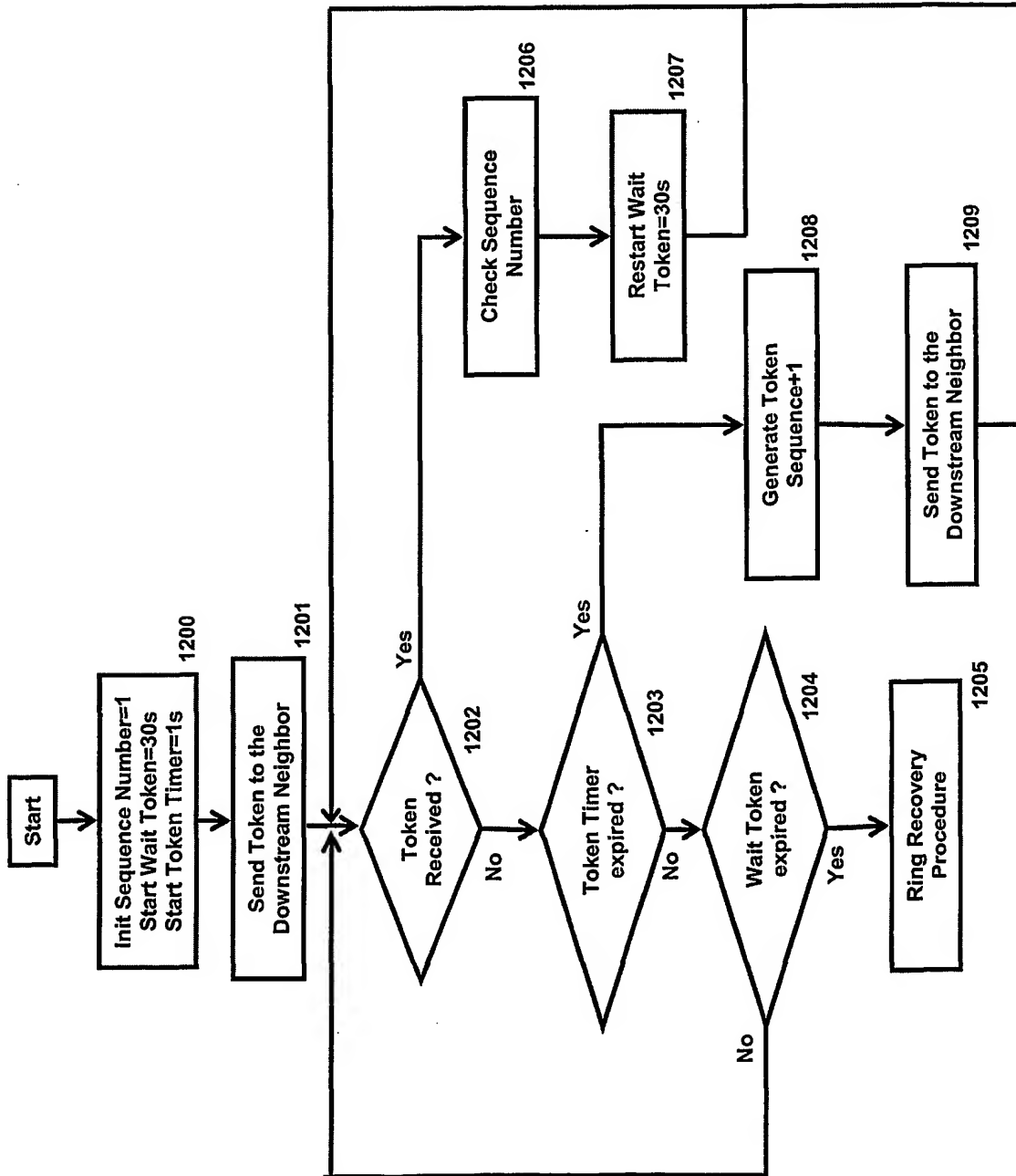
Figure 12: Virtual Ring Manager: Token Management

Start

Send an Insertion Request to the Virtual Ring Manager 1300

Start Insertion Timer 1301

Insertion Confirmation received 1302

Yes → Stop Insertion Timer Update Neighbor addr 1304 → Procedure End OK 1305

No

Insertion Timer Expired 1303

Yes → Send Insertion Request to Backup Manager 1306 → Re-Start Insertion Timer 1307

No

Insertion Confirmation received 1308

Yes → Stop Insertion Timer Update Neighbor addr 1310 → Procedure End OK 1311

No

Insertion Timer Expired 1309

Yes → Procedure End KO 1312

No

Figure 13: Node insertion - Algorithm in the inserting Node
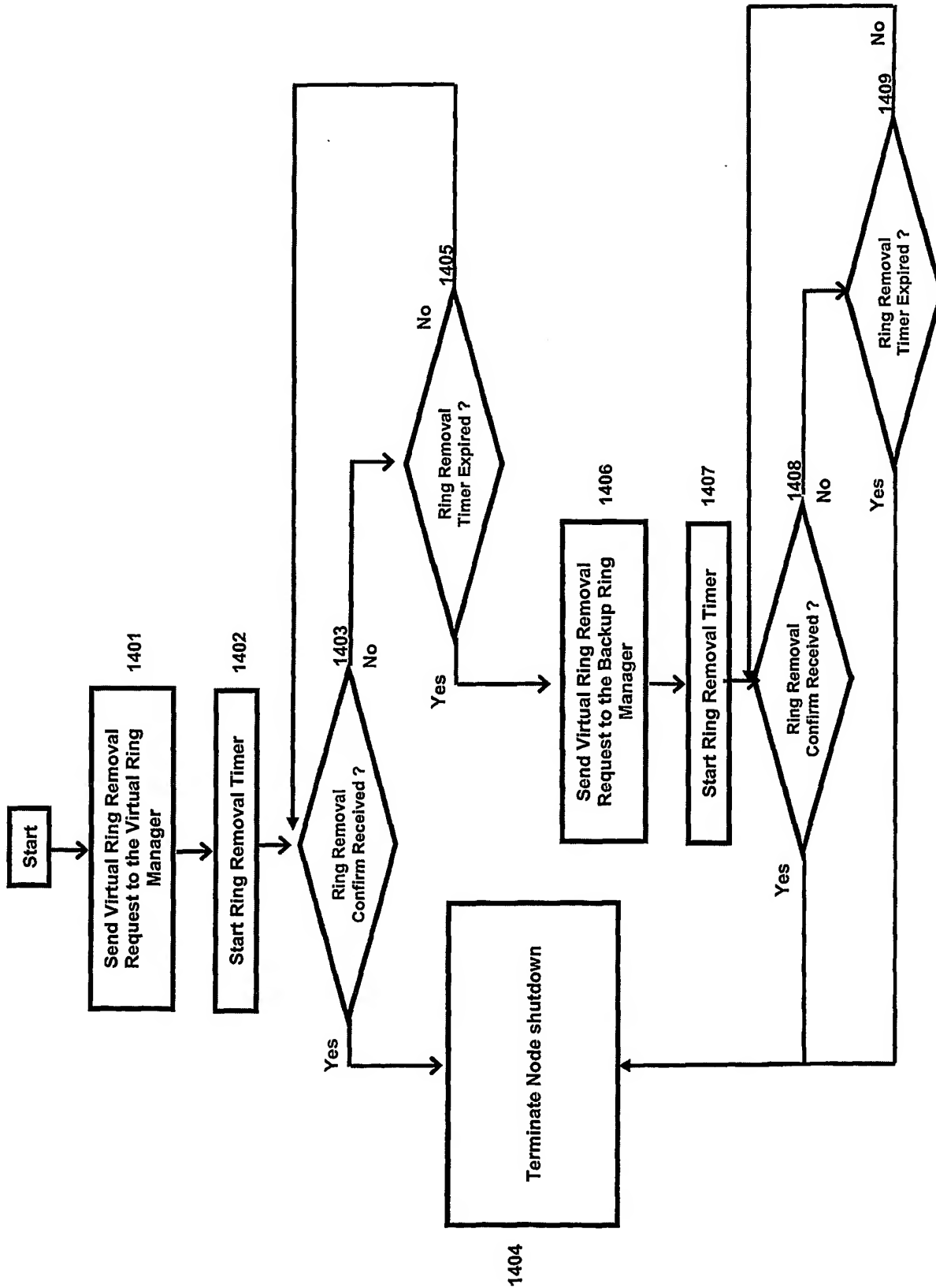
Figure 14: Node removal - Algorithm in the removing node

```
┌──────────┐
│  Start   │ 1500
└────┬─────┘
     │
     ▼
    ╱╲
   ╱  ╲
  ╱ Virtual╲
 ╱  Ring    ╲  No
╱ Change     ╲──────────┐
╲ Neighbor   ╱          │
 ╲ message  ╱           │
  ╲received?╱           │
   ╲  ╱                 │
    ╲╱  1501            │
     │ Yes             │
     ▼                 │
┌──────────────────┐   │
│ Update Upstream  │   │
│ and Downstream   │   │
│ Neighbor IP      │1502│
│ address with the │   │
│ new address given│   │
│ in the Virtual   │   │
│ Ring Change      │   │
│ Neighbor message │   │
└────────┬─────────┘   │
         │             │
         ▼             │
┌──────────────────┐   │
│ Send a Virutal   │   │
│ Ring Neighbor    │1503│
│ Changed message  │   │
│ to the Virtual   │   │
│ Ring Manager     │   │
└──────────────────┘   │
```

Figure 15: Node insertion/removal - Algorithm in the Adjacent Nodes

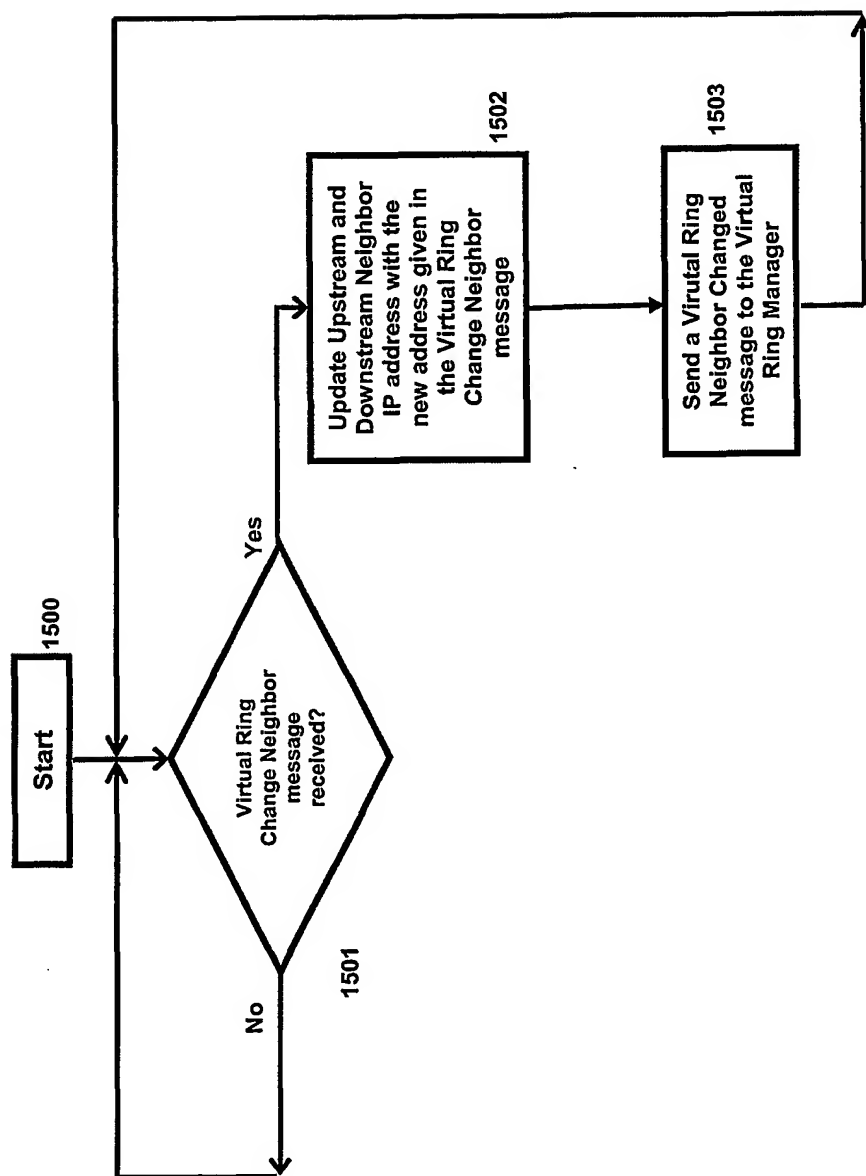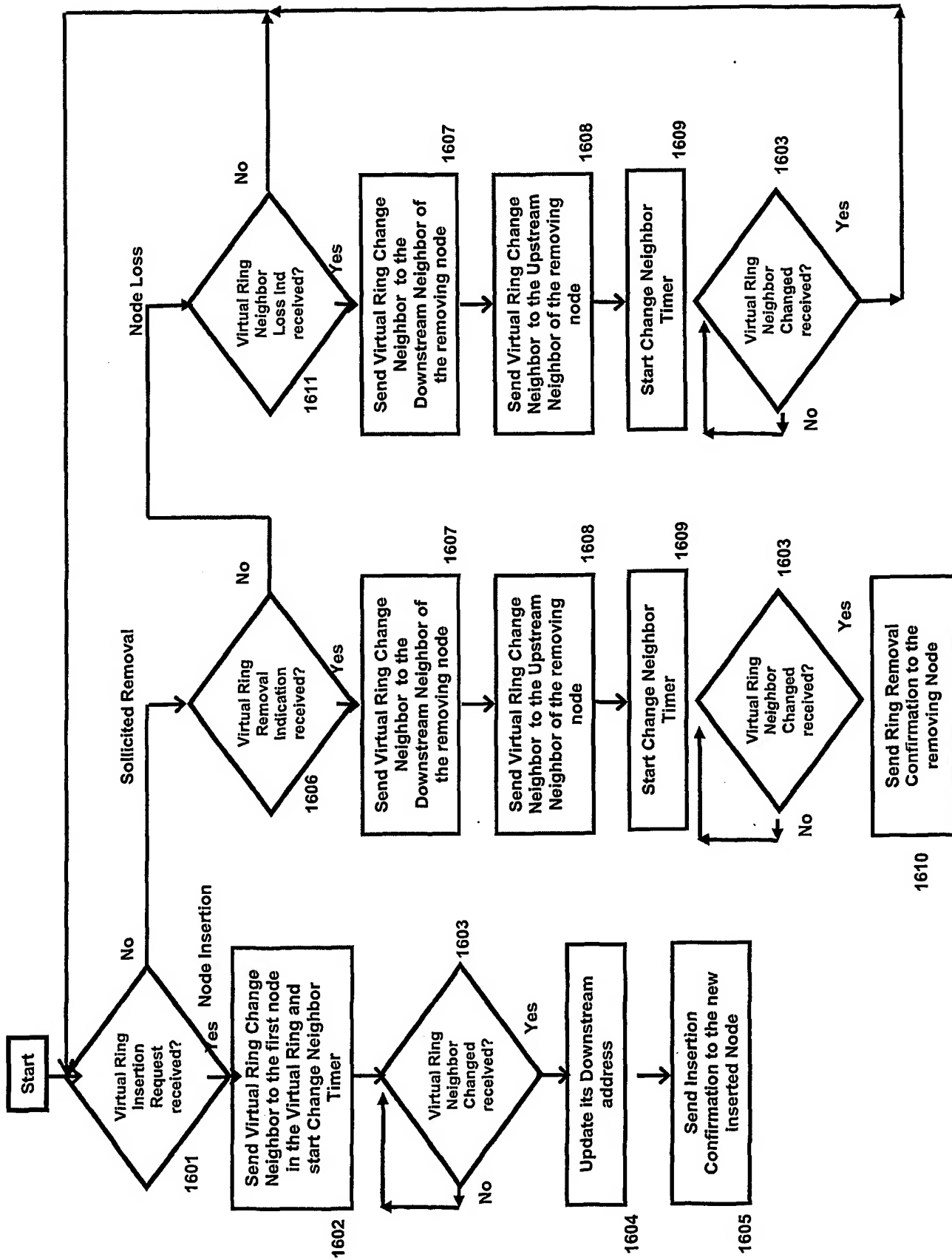Figure 16: Node insertion/removal - Algorithm in the Virtual Ring Manager

Node F
(VRM downstream Neighbor)

Up	E
Down	A
VRM	E
BRM	B

1703

Virtual Ring
Manager E

Up	D
Down	F
VRM	E
BRM	B

1702

Inserting Node
G

Up	
Down	
VRM	E
BRM	B

1701

Virtual Ring Insertion Request
(IP address G)
1704

Start Instertion
Request Timer

Virtual Ring Change Neighbor
(Upstream @=G, Downstream @=0.0.0.0)
1705

Start Change
Neighbor Timer

Up	G
Down	A
VRM	E
BRM	B

1706

Virtual Ring Neighbor Changed
1707

Up	D
Down	G
VRM	E
BRM	B

1708

Stop Change
Neighbor Timer

Virtual Ring Insertion Confirm
(Upstream @=E (VRM), Downstream @=F)
1709

Stop Instertion
Request Timer

Up	E
Down	F
VRM	E
BRM	B

1710

Notes: Node Ring Record
Up: Upstream Neighbor IP @
Down: Downstream Neighbor IP @
VRM: Virtual Ring Manager IP @
BRM: Backup Ring Manager IP @

Figure 17: Flow of a Node Insertion

Upstream Node B 1801

Up	A
Down	C
VRM	E
BRM	B

Removing Node C 1802

Up	B
Down	D
VRM	E
BRM	B

Downstream node D 1803

Up	C
Down	E
VRM	E
BRM	B

Virtual Ring Manager E 1804

Up	D
Down	G
VRM	E
BRM	B

1805   Virtual Ring Removal Request
(IP address C, Upstream @=B, Downstream @=D)

Start Ring Removal Timer

1806   Virtual Ring Change Neighbor
(Upstream @=B, Downstream @=0.0.0.0)

Start Change Neighbor Timer

1807   Virtual Ring Change Neighbor
(Upstream @=0.0.0.0, Downstream @=D

Up	A
Down	D
VRM	E
BRM	B

1808

1809   Virtual Ring Neighbor Changed

Up	B
Down	E
VRM	E
BRM	B

1810

1811   Virtual Ring Neighbor Changed

Stop Change Neighbor Timer

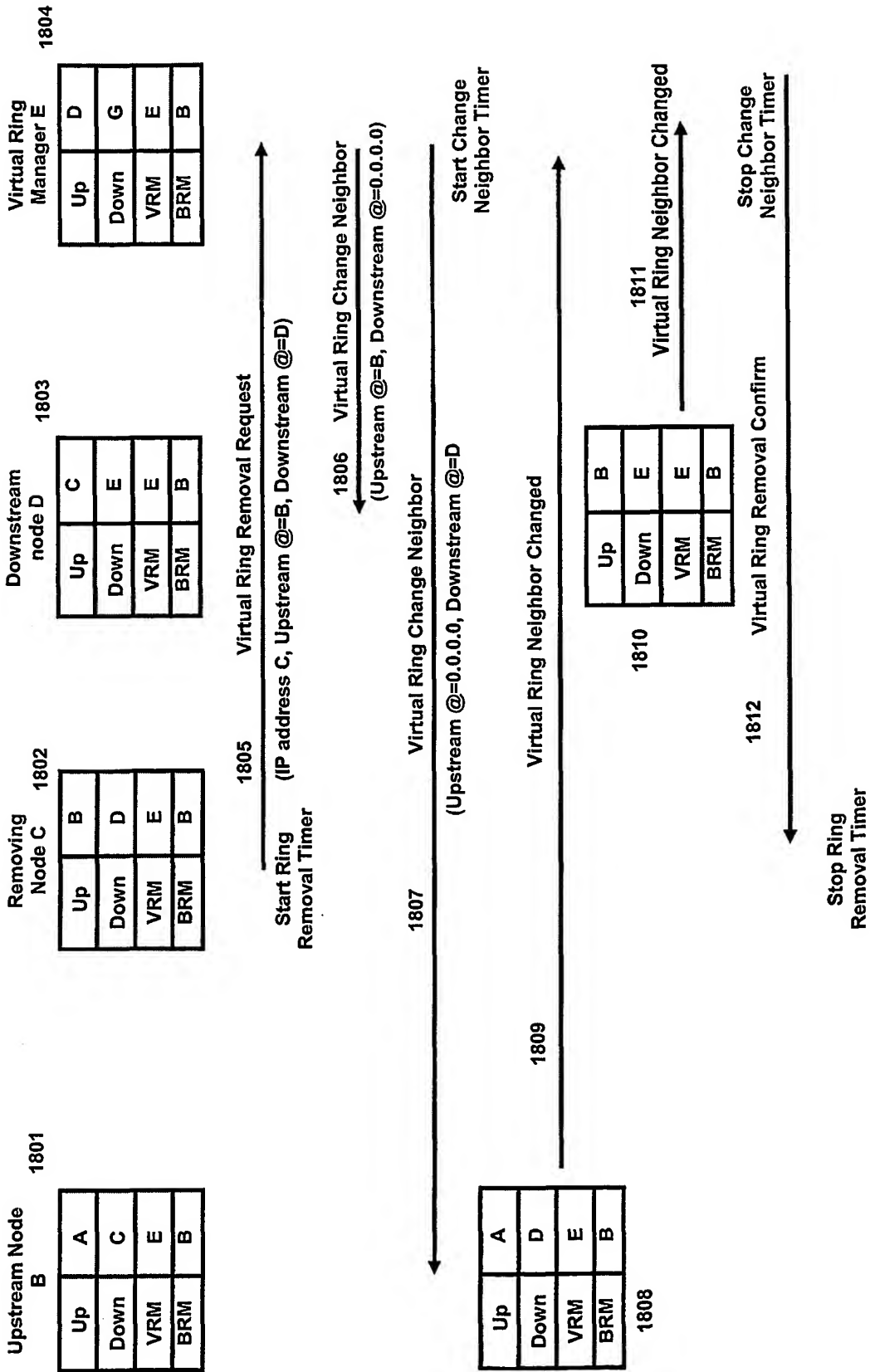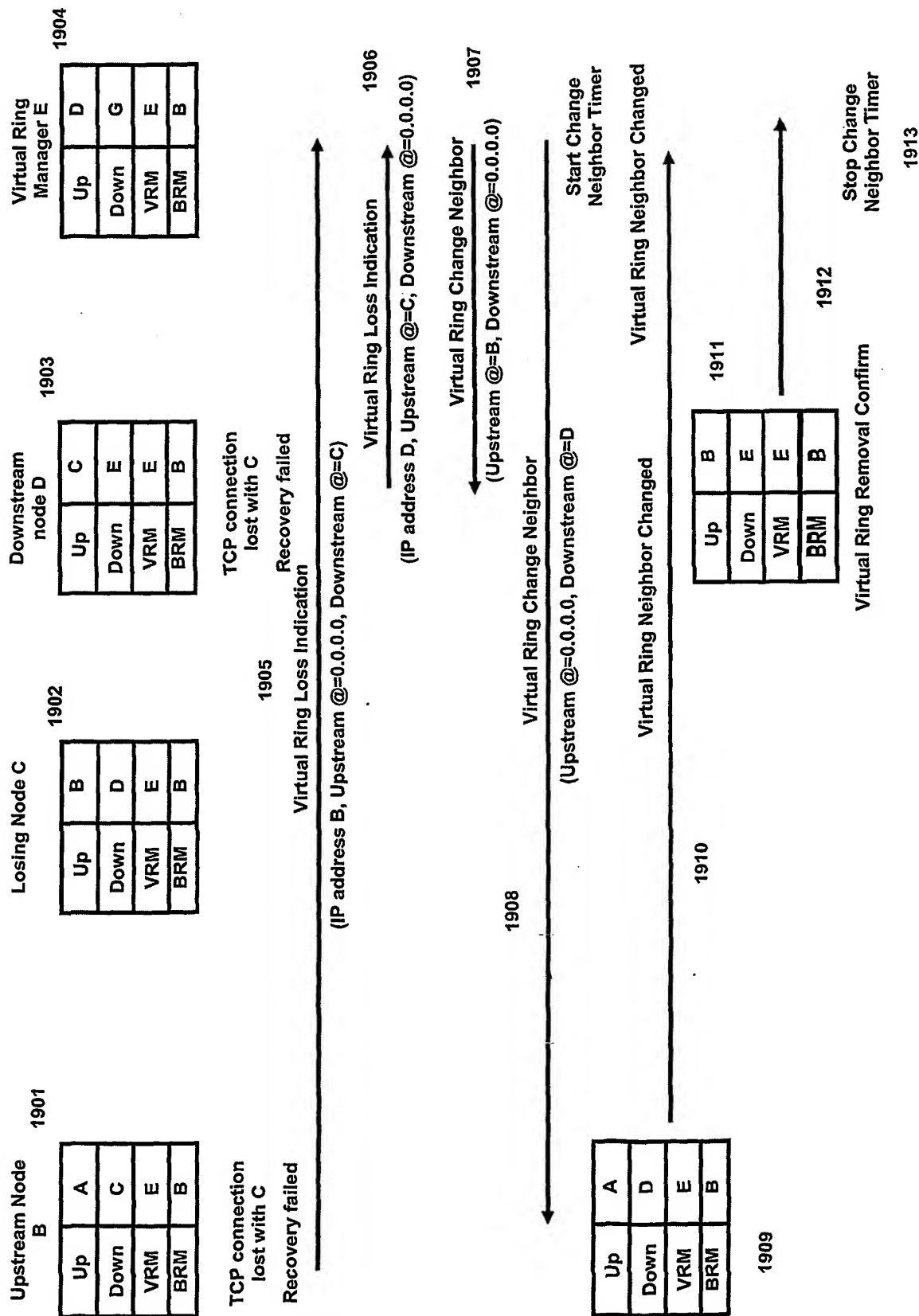1812   Virtual Ring Removal Confirm

Stop Ring Removal Timer

Figure 18: Flow of a Node Solicited Removal

Figure 19: Flow of a Node Loss